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DUPLEX TELEGRAPHY.

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(Continued from page 279).

I WILL now explain the irregularities in working to which circuits are liable when duplexed, their causes, and the means adopted, by the different methods introduced, to remedy or reduce their effects. They are due (1), to variations in resistance; (2), to electrostatic induction; and (3), to electro-magnetic induction.

1. *Resistance.*

The *resistance* of a body is the obstruction which it offers to the transference of electricity through it. The reverse quality, viz., the facility which it offers to this transference, is termed its *conductivity*. These are reciprocal terms, and being practically synonymous, the latter word has almost disappeared from the vocabulary of the telegraph engineer. The obstruction and facility to the passage of the current through a circuit are similarly implied by the term resistance. A mass of great resistance obstructs, and a mass of small resistance facilitates the flow of electricity. Reciprocally the latter is said to conduct well, and the former to conduct badly; and if the bad conductor conduct very badly, it is said to *insulate*. Hence *insulators* are masses which oppose great resistance, *conductors* are masses which oppose small resistance to the flow of electricity through them. In this way insulation and conduction are both implied in the single term, resistance.

Now all telegraphs between any two points connected together consist of conductors supported by insulators stretched or laid either in the air, beneath the ground, or under the sea. In the air we have iron wires, which offer little resistance, supported at intervals by earthenware, porcelain, or glass knobs, which offer very great resistance. Beneath the ground and under the sea we have copper wires, which offer even less resistance than the iron, entirely enveloped by several layers of gutta-percha, india-rubber, or other compounds which offer the greatest possible known resistance to the passage of the current.

In the first case, the practical insulator, or the material which resists the escape of the current, is not so much the earthenware or glass itself which forms the support, as the water or moisture which is deposited upon its surface. Hence, aërial insulation is reduced to a question of form, and immense ingenuity has been expended in devising the best form of surface to give the greatest amount of resistance in the worst kind of weather. In the second case, the insulator is the mass of the substance itself, and its efficiency depends entirely upon the nature of the material, upon its thickness, and upon the skill with which the different layers have been laid and the different joints made. In the air insulation is a question of exposed surfaces; underground and submarine it is a question of enclosed masses.

Let us, in the first place, assume our two stations, A and B, connected together by an aërial telegraph consisting of an iron wire supported at every 100 yards upon an earthenware insulator fixed to an arm upon a pole. The air itself is practically an absolute insulator; dry air is the most perfect insulator known. If the wire could be stretched from A to B without any support at all, all the current which left A would reach B without any diminution or loss; but, inasmuch as it must be supported at intervals of about 100 yards by masses which are not absolute insulators, but which allow a small portion of the current to pass through or over them, the current which arrives at B must necessarily be less than that which leaves A.

Precisely in the same way, if we had a pipe conveying water punctured with a small hole at every 100 yards, through each of which a thin stream leaked, the amount of water which arrived at the distant end would be less than that entering the near end by the amount which escaped. On the other hand, if the pressure at the near end be maintained constant, the absolute amount of water which enters the pipe at that end is greater when the pipe is leaky than when it is whole.

Thus we see that, since every insulator is a leakage or an additional outlet for the current, more electricity will leave A when these supports are used than would be the case if the wire were stretched supportless. Hence they have the same effect upon the current leaving A as the reduction of the resistance of the wire. In fact, these leakages do reduce the resistance of the circuit. I have already pointed out that the strength of the current is merely a function of its resistance when the difference of potential remains constant. If the strength increases with the same electro-motive force, it is due to a diminution of resistance; if the strength diminishes under the same conditions, it is due to an increase of resistance. Hence, any variation in the resistance of the circuit affects the currents leaving A, and this variation is produced either by an alteration of the physical condition of the mass of the conducting wire, or by a change in the character of the mass or surface of the insulating material. It follows, therefore, that the strength of the currents which flow from A to B are dependent, first, upon the resistance of the aërial wire, and, secondly, upon the resistance of the insulators that support that wire.

Now, the resistance of the wire itself is only affected by the changes which occur in its temperature. Resistance is unquestionably a property of the molecules of matter. Any variation in the condition of these molecules disturbs their capacity for the transference of electricity. Heat has this influence. As the temperature of a metal increases or diminishes, so does its resistance. Iron wire increases in resistance 0·21 per cent for each degree (Fahr.) through which it is raised. The diurnal variations of temperature in this climate are not great; in summer the greatest range is about 30°. This would not practically affect the comparatively short circuits we use, but in India and America, where the circuits are much longer and the daily variation much greater, considerable difference must be experienced in the resistance of the wire as between midday and midnight.

But the resistance of the insulating supports varies incessantly. The resistance which the mass of an insulator offers to the current is prac-

tically constant, but its surface is incessantly undergoing change by the deposition of moisture and dirt upon it. I have mentioned that it is the moisture and dirt which are practically the insulator, and hence insulators owe their efficiency more to the form of their surface than to the quality of their substance. The resistance of an insulator is therefore practically the resistance of the layer of water condensed or deposited on its surface. Hence, every shower of rain, fog, dew, and mist affect its resistance. Lines exposed to the spray of the sea or to the smoke of manufactures are peculiarly liable to variations.

Thus it happens that the resistance of an aërial telegraph is constantly varying, and therefore the currents which flow through it are constantly subject to change. The longer the line the greater must be the extent of this variation. The amount of variation depends essentially upon the character of the country through which the line passes and the nature of the weather. The resistance of some lines varies as much as 50 per cent in one day in bad weather, while in fine weather it remains practically constant. Short lines, as a rule, are little disturbed by variations of short duration, but long lines of 200 miles and upwards are the subject of constant variations due to atmospheric changes at different points. A thunderstorm here, a shower there, excessive radiation at one point, cloudiness at another point—all tell their tale.

In England we are peculiarly liable to great variations in the resistance of our lines, not only from the excessive moisture of our climate, but owing to the special means which we have taken to prevent the escape of currents from one wire to another on the same pole, which occurs either with indifferent insulators or with broken and defective ones. This is due to "earth wiring," or the erection of iron wires on every pole, to allow the leakage at once to pass to earth without interfering with any other wire.

As an illustration of the changes of resistance in a line 280 miles long, I give the records of two days —the one a wet day, and the other a fine day:—

Weather at Recording Station.	Time.	Resistance in ohms.
	A.M.	
Wind S.E. 13th September—		
Showery	12.30	2476
Rain	10.25	2272
,, ...	11.10	2086
Heavy Rain ..	11.15	1611
,, ,, ..	11.50	2272
	P.M.	
Rain	2.55	2476
,, ...	3.25	2700
,, ...	4.15	2476
,, ...	4.17	2272
Clearing up ..	4.50	2476
,, ,, ..	5. 5	2272
,, ,, ..	5.20	2086
Fine	5.25	1917
,, ...	5.28	2947
,, ...	9.40	2423
Fog	9.45	2133
,, ...	10. 0	2476
Wind N.W., 18th September—		
	A.M.	
Fine	9.40	3714
	P.M.	
,, ...	5. 0	3407
,, ...	7.15	2874

It will be seen how rapid and sudden were the changes in the former case, and how constant those in the latter. The sudden depression at 11.15 a.m. on the 13th was probably due to some severe weather occurring on some portion of the line. The fall on the evening of the 18th was probably due to the formation of dew. As an interesting record of the daily variations of a line in England, I give the resistance in ohms at midday and midnight for every day for a month:—

Date.	Midday.	Midnight.
Sept. 1	3222	3128
,, 2	3714	2640
,, 3	3714	3714
,, 4	4421	4421
,, 5	4050	3350
,, 6	4421	3407
,, 7	4050	4050
,, 8	4000	3128
,, 9	2272	3128
,, 10	3714	1611
,, 11	4050	3714
,, 12	3714	2874
,, 13	2272	2476
,, 14	3407	2476
,, 15	3128	3714
,, 16	3714	2272
,, 17	1916	2947
,, 18	3714	2874
,, 19	1916	1350
,, 20	2272	2947
,, 21	2947	2947
,, 22	3714	3714
,, 23	3714	3128
,, 24	4050	4050
,, 25	4050	2874
,, 26	3407	3407
,, 27	3714	2272
,, 28	4000	3572
,, 29	3891	2378
,, 30	3407	2640

But there are other causes besides wet weather which interfere with the constancy of the resistance of an aërial wire. It may be brought into contact with other wires upon the same poles by the position of the pole itself being disturbed, by falling branches, trees, or rocks, by high loads at crossings, by whip lashes, by kite strings and cotton waste, by careless workmen, and even by the wind itself when very high. Loose or broken stays may place the wire in contact with signal posts, walls, bridges, and trees. Trees, unless carefully lopped, may grow up amongst the wires. Joints may become bad from the absence or failure of the solder. Malicious or thoughtless persons may twist them together. Various moving accidents by flood and field disturb the wires, and these disturbances are evidenced by varied resistance. But subterranean and submarine wires are free from all these vicissitudes. The resistance of their insulating coating is practically constant. Cables lie beneath the sea upon a cushion of equable temperature, and they are far removed from atmospheric disturbances.

But the potentials at the extremities, as well as the resistance of the line, may vary. The variation of the difference of potential has the same effect upon the currents as the variation of resistance. The potential of the earth varies at different times and in different places from some unknown cosmical cause. By this variation of the difference of potential at the extremities of a line, currents are pro-

duced in our wires called *earth currents*, which vary both in direction and strength sometimes rapidly, sometimes slowly. Lines running easterly and westerly are much affected by them, but not so much those running north and south. They are always more or less present, and vary diurnally with much regularity, apparently following the motion of the earth about its axis. These daily currents do not much disturb the working of our circuits, though they tend to diminish the speed of working of those long circuits which are exposed to their influence. For instance, between London and Dublin the rate of working invariably diminishes towards noon, when these currents are at their maximum.

It is, however, their occasional and exceptional variation which disturbs the working of circuits. All great terrestrial and atmospheric changes are accompanied by electrical disturbances especially those which culminate in auroræ thunderstorms and earthquakes. Auroræ especially are generally preceded by currents of great strength, overcoming entirely the working currents, and breaking down the ordinary telegraphs. These currents are sometimes steady, but they more generally vary rapidly in strength and duration. Thunderstorms are also accompanied with current effects which disturb the working of the wires, and there are many authentic cases of such currents preceding earthquakes.

In fact, telegraph wires are in a constant state of change, and it was this variation in their condition which rendered the earlier experiments in duplex telegraphy a failure.

(To be continued).

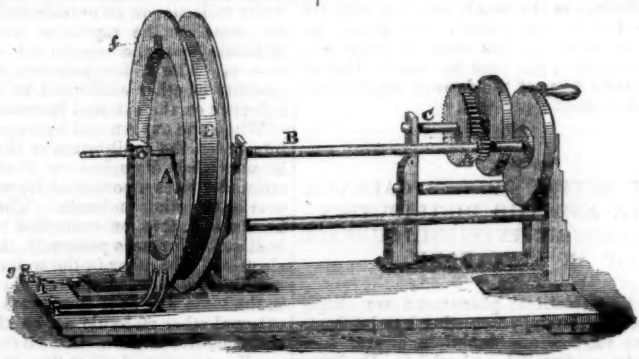
THE ELECTRIC RESISTANCE OF MERCURY IN ABSOLUTE MEASURE.*

By M. LORENZ.

The various determinations of the electric resistance of mercury in absolute measure by Weber, the Committee of the British Association, and Kohlrausch, notwithstanding much care in experiment, are somewhat discordant. The methods all agreed in the use of induced *currents* of *variable* strength. As this appeared to me to be the source of discrepancy, I have sought for some other way in which a *constant* electromotive force, *without* current, might be employed.

* Abstract of paper in "Poggendorff's Annalen."

The annexed figure shows the apparatus I have used. A brass disc, A, is fixed at the end of an easily-turned axis, B, connected by wheel-work at the other end with another axis (each axis having a driving-wheel. The disc, A, turns within a mahogany ring very little larger, and fixed to a stand, D, movable in the direction of the axis. The ring is wound round with several regular coils of silk-covered copper wire 1 m.m. thick. The upper part of the stand carries a brass rod, the point of which can be pressed against the centre of the disc, and thus the disc be electrically connected with the binding-screw, *g*. Another binding-screw, near this, is connected with a thin brass slip, which, fixed to the wooden ring, presses against the disc. Two other binding-screws, *h*, are connected with the wire passing round the ring.



If, now, an electric current is sent through the ring wire, and the disc put in rotation, there arises, through induction, a difference of tension between the centre and the periphery of the disc, and if the screws *g* be connected with a multiplier, a deflection will be observed. The principal current is now passed through a conductor whose resistance is to be measured, *e.g.*, through a column of mercury in a cylindrical glass tube, two platinum wires being soldered into the walls of the tube. This derived current is introduced into the circuit of the induced current in such a way that both currents pass by the same path to the multiplier. The disc is now rotated in such a direction that the two currents are contrary to each other; and with a certain velocity of rotation, they will exactly *neutralise* one another, so that the needle comes to zero. This velocity of rotation, multiplied by a constant calculated for the apparatus, will give the absolute resistance of the mercury column between the platinum wires. Let w be this resistance, and s the strength of the principal current, then the electric difference of tension in the platinum wires is $s\,w$. Further, let P denote the difference of tension between centre and periphery of the disc, when the intensity of the principal current is unity, and the disc is turned with uniform velocity in the second. Then, if the intensity of the principal current is s, and the disc rotates n times in the second, the electromotive force, from induction, is $P s n$. Now, $s w = P s n$, and hence $w = P n$, if the multiplier shows no current. The resistance is, therefore, independent of the intensity of the principal current, and the measurement is limited, if once the con-

stant, P, of the apparatus is known, to determining the number of rotations of the disc in a second for each resistance to be measured.

I had thought to ascertain the velocity of rotation by electric apparatus, but unexpectedly obtained great accuracy through simply turning with the hand, and counting the revolutions, while the time was given by the minute beats of a clock. One double chromic acid potash element was a sufficient electromoter. [Various precautions taken for avoidance of errors, are detailed. The author also shows how he estimated the constant of the apparatus].

From a series of experiments with different-sized tubes, different quantities of mercury, &c., it is found that on the average 1 mercury unit=0·9337 Ohm's unit. Or, the mercury unit is equal to $0{\cdot}9337 \cdot 10^{10}$ absolute units.

This result, in which the error could hardly exceed 0·2 per cent, is about 2 per cent under that obtained by the British Committee (0·9629 and 0·9564 Ohm's unit), which, again, is lower than that by other observers (Kirchhoff, perhaps, excepted,) as Weber gives the value 1·0257 Ohm's unit, and Kohlrausch, 0·9705.

I will here mention some other experiments I made with my apparatus. If the principal current is interrupted while the disc is turned, and the needle stands at zero, the needle receives an impulse, and is deflected several degrees. The direction of this proves that the derived current, at the moment of interruption, prevails over the current induced in the disc.

Experiments were also made with an intermittent principal current. They gave, for the measured resistance, a result about 1 per cent too high, but I ascribe this difference to error of observation, because in these experiments it was more difficult to keep the needle at perfect rest, and, with a restless state of the needle, one is inclined (according to my experience) to turn the disc too quickly.

I made some experiments to find whether the length of the mercury column above the upper platinum wire had any influence on the result. This length, in the experiments described, was about as great as the distance between the two platinum wires. Mercury being removed from above, no difference in the result was met with till the mercury surface was about 1 m.m. above the upper platinum wire. In this case, the resistance observed was about 1 per cent too small; that is, the electromotive force of the derived current was now diminished about 1 per cent.

ON THE

CHEMICAL ACTION OF THE GALVANIC CURRENT, AND THE DISTRIBUTION OF FREE ELECTRICITY ON THE SURFACE OF AN ELECTRODE.

THE theory that electrical phenomena are simply phenomena of the luminiferous ether has lately, as many of our readers are doubtless aware, been enunciated by a Swedish physicist, Professor Edlund. About two years ago he communicated to the Stockholm Academy a paper in which the theory was partly developed; an explanation being given of electrostatic attractions and repulsions, electrodynamic phenomena, galvanic induction phenomena, and rotation of the plane of polarisation through the action of a current. The subject heading this note was also touched upon, though briefly; but has been more fully discussed in a later communication to the Academy, which appears in a recent number of *Poggendorff's Annalen*. The first point considered is the chemical action of a galvanic current, and the following may be taken as a brief account of the author's explanation of this phenomenon.

Whatever idea may be formed of the nature of electricity, we must suppose, in order to explain the decomposing power of the current, that electricity has an unequal action on the matters separated from each other. It must either attract one substance and repel the other, or attract or repel both, but with unequal force. Now we know, from the physical doctrine of light, that material bodies have the power of attracting ether molecules, and of condensing ether in their interior, until the attraction by the matter for an external ether molecule is just as strong as the repellent force of the condensed ether on the same molecule. A material body, with its condensed ether, has thus, on the whole, no influence on the external free ether; and this is the case whether the free ether is in motion or at rest. Again, it is known, that different kinds of matter have unequal attraction for ether molecules. Some attract them more strongly than others. The quantity of ether held condensed by the oxygen molecules in a mass of oxygen is not equal to the quantity held condensed in a hydrogen mass, &c. We may take water for one example of an electrolytic fluid; and if we denote the quantities of ether condensed by the two constituents, by e_o and e_h respectively, then e_o and e_h are unequal. The attraction of an external ether molecule to the oxygen molecule is just as strong as its repulsion by the condensed quantity e_o; and similarly, the attraction of the external ether molecule to the hydrogen molecule is just as strong as its repulsion by e_h.

Now when the oxygen and hydrogen molecules unite to form water, we must suppose that the water molecule formed contains a quantity of ether $e_o + e_h$ in condensed state. The attraction of the water molecule on an outside molecule is again just the same as the repulsion between this ether molecule and the condensed quantity of ether $e_o + e_h$. The water molecule, together with the quantity of ether condensed by it, is thus without influence on the external free ether.

When the oxygen and hydrogen molecules unite into water, the equilibrium of the condensed ether is somewhat disturbed, so that one of the two molecules loses a portion of its supply, which gives over to the other molecule. This agrees with the known fact, that on contact of two heterogeneous bodies, one becomes positively, the other negatively electric. The ether in the water molecule is thus not divided between the two chemical constituents in the same way as if these were free. If, now, an external ether molecule act on the water molecule, that constituent of water which contains a somewhat smaller quantity of ether than in the free state will be attracted, and the other repelled. The first constituent will thus tend towards the external molecule, and the mass of ether contained in the water molecule will be driven more and more, by the repellent force, to the retreating constituent of

the water. Thus the force which seeks to separate the hydrogen from the oxygen ever grows, till at last the chemical combination ceases to exist. It is clear that, on this conception of the phenomenon, the repulsion of the one constituent of water, or rather the mass of ether which this constituent contains in excess, is equally great, with the attraction for the other constituent.

The author develops these principles mathematically, and shows how they apply to several facts of electrolysis.

Experiment has shown, that the weakest current passing through a liquid decomposes it. We must accordingly suppose that the weakest current is capable of transferring the ether from the oxygen molecules to the hydrogen, or conversely. In proportion as the ether molecules are thus transferred, the power of the current to separate hydrogen from oxygen grows till the chemical combination is dissolved. All depends on the ease with which the ether molecules are transferred from one constituent to the other.

That the equilibrium of ether in the water molecules is not unstable may be thus explained: when the water molecule, as is generally the case, is in a mass of ether at rest, it is clear that the position of equilibrium of the ether condensed by the oxygen and the hydrogen depends, in great part, on the free ether with which it is surrounded. The pressure of the free ether on the condensed is nearly equal on all sides. If now the pressure of free ether be in any way altered on one side, the condensed ether molecules will necessarily change their position of equilibrium. But this is exactly what occurs when the water molecules come into the galvanic current. It is not conceivable that the condensed ether remains undisturbed in its position, when the free ether about it begins to move. One constant hindrance to the motion of the ether molecules from one constituent of water to the other is, however, the galvanic resistance of the conductor. But this is proportional to the strength of the current, that is, proportional to the velocity with which the movement takes place. Thus the resistance does not render it impossible for the weakest current to transfer the ether from one position to the other.

We now come to the author's explanation of the distribution of free electricity (or free ether) on the surface of a galvanic electrode.

Suppose a tube, the gaseous mass in which is put in motion by a force operating at one end, the gas streaming freely out of the other end. We understand that the resistance of the tube to the motion of the gas is proportional to its length. Calling the distance from the open end to a given cross section, x, the resistance in this section is proportional to x. Let D' denote the density of gas in that section, and D the density at the open end of the tube; then, as soon as the motion has become constant, the difference D'−D is proportional to the distance x. The density of the gas increases from the open end to the end where the force acts.

Conceive, now, that the two ends of the tube are united, so that the moving gaseous mass is quite enclosed. The gas must then be just as much rarefied in one portion of the tube as it is condensed in the other, and at the transition surface between the two parts the gas has the same density as if it were at rest. If the tube is of the same thickness and nature throughout, this transition surface divides it into two parts of equal length. At equal distances from this surface the condensation on the one side is just as great as the rarefaction on the other. If the resistance in one part of the tube is greater than in the other, then the transition surface is shifted so far towards the part which has greatest resistance that the resistance in the whole of this portion (reckoned from the transition surface to the place where the force acts) is just as great as the resistance in the whole of the other portion. If D and D' denote the density of the gas at the transition surface, and at any other surface on the side on which the gas is condensed, then $D'-D=a\,m$, where a is a constant, and m is the resistance from the transition surface to the surface just referred to. If D'' is the density of the gas at any other surface, on the other side of the transition surface, then similarly $D-D''=a\,m''$, where m'' denotes the resistance between the surfaces specified.

These principles find immediate application to the current ether. It has the property, like an ordinary gas, of communicating pressure in all directions, because its molecules are readily movable. The circumstance that an electrical body has the same optical properties as in the normal state, indicates that the elasticity of the free ether is proportional to its density. Accordingly, what has been said about an ordinary gas will hold good for the ether. The only difference is that the condensation and rarefaction of the ether can only take place at the surface of the galvanic conductor, and not in the interior, because the ether molecules repel each other.

In a closed galvanic circuit the ether is, on one side, put in motion by the electromotive force. It must therefore be condensed on that side of the electromotive force, whither the current goes, and consequently rarefied on the other side. The transition surface is in such a position that the galvanic resistance of the conductor from this surface to the point where the force is working is just as great on the one side as on the other. Call the strength of current s, the density of ether at the transition surface, or (the same thing) the density of ether at rest, D, its density at any two surfaces on the condensation side D' D'', and on the rarefaction side D_o' D_o''; further, the resistance for the unit of current strength between the transition surfaces and the surfaces named, m' m'' m_o' m_o''; we have (since the resistance is proportional to the strength of current), $D'-D=m's$; $D''-D=m''s$; $-(D_o'-D)=m_o's$; $-(D_o''-D)=m_o's$. But D'−D, D''−D, $D_o'-D$, $D_o''-D$, are no other than the electroscopic tensions of the respective surfaces, the two first positive, the two last negative. If we call the former T' and T'', and the latter T_o' and T_o'', we have—

$T''-T''=(m'-m'')s$ and $T_o'-T_o''=(m_o'-m_o')s$
$T-T_o'=(m'+m_o')s$ and $T''-T_o''=(m''+m_o'')s$.
That is, the difference between the electroscopic tensions for any two points on the surface of the conductor is proportional to the product of the strength of current and the resistance for the unit of current strength between these points.

Calling m the resistance of the whole circuit for the current strength 1, and T the tension in the immediate neighbourhood of the electromotive

force; then, as the resistances between the transition surface and the point where the force acts are equal on both sides, we have—

$$s = \frac{2T}{m} = \frac{E}{m}$$

which, it is known, agrees with experiment.

On closer consideration (Prof. Edlund concludes) one finds that the experiments made to determine the distribution of electricity on the surface of a galvanic conductor, leave it quite uncertain whether this is in motion or at rest. It is merely affirmed that the ether on the surface of the conductor has a greater or less density than in the normal state, and consequently shows a certain tension. We, therefore, do not for the present enquire whether the ether which produces electroscopic tension is at rest or in motion.

KOHLRAUSCH ON ELECTRICAL MEASUREMENTS.

Much has been written upon Electrical Measurement, yet within a certain limit much of what has been written is confined to the method of the measurement, and not to its accuracy. The advent of a work*—the translation from the German of Prof. Kohlrausch's "Physical Measurements,"—devoted entirely to accuracy, or perhaps it should be said to the elimination of error, is a matter of more than passing interest to the electrician. Those electrical laws that make themselves manifest on the crudest of instruments have been read and recorded; investigators in the future will derive most profit who employ the most accurate method. Prof. Kohlrausch has so long been known as an authority in experimental method—measurements recorded in his laboratory have always stood the test of so lengthened verification—as to have drawn students to his chair from all parts of the world. The issue of a work from his pen, and the translation of this work into English, is an event of so high importance that too great stress can scarcely be brought to bear. We propose, then, to place before our readers a selection from Dr. Kohlrausch's work—his simple remarks on the measurement of currents with the tangent galvanometer. For the calculation of the errors of observation, the mean and probable error, the determination of empirical constants by the method of east squares, &c., we must refer to the work itself; it would be impossible to condense, and to extract would be useless.

The case first treated of is that of relative measurement by the tangent compass, in which we are told the "angles of deflection should be neither very large nor very small, those of about 45° being most advantageous. It is necessary, therefore, for currents of very different intensities to employ galvanometers of different degrees of sensitiveness; that is, with coils of different diameters or of different lengths, or the instrument may be so constructed that the current may be passed through a greater or less number of coils as required. The results of different instruments may be compared with each other by passing the same current through both at once. If, for instance, we obtain in this manner a deflection of 66·5° in the first instrument, and of 14·2° in the second, the tangents of the deflection of No. 1 must be multiplied by—

$$\frac{\tan 14{\cdot}2^\circ}{\tan 66{\cdot}5^\circ} = \frac{0{\cdot}253}{2{\cdot}30} = 0{\cdot}110,$$

to make them comparable with those of No. 2.

"The tangent-compass is usually adjusted so that the needle points to zero when the plane of the coils is in the magnetic meridian. Whether this is accurately the case must be tested, preferably by the employment of a very short needle, for the proportionality of current-strengths to the tangents of the angles of deflection only holds good if the instrument be exactly placed, and especially so with powerful currents. This difficulty may, however, be easily avoided by passing the current successively in opposite directions through the galvanometer, and taking the mean of the deflection to both sides (half the combined deflection) as ϕ. In the value thus obtained, errors from incorrect position are eliminated. It is convenient for this purpose that a commutator should be permanently connected with the galvanometer, which will allow the current to be reversed without altering any other part of the circuit. This gives the additional advantage of a double degree of accuracy, and renders it unnecessary to observe the zero-point exactly; and, lastly, a well-arranged commutator serves conveniently to open and close the circuit."

The deviation from the law of proportionality of tangents is then considered, with the best means of bringing the needle to rest. Valuable as the matter would be, we cannot here enter into the measurement of currents in absolute magnetic units with the tangent-compass, &c. There is one more quotation that will recommend itself to the reader, and it relates to measurement with reflecting instruments, to the reduction of observations with the scale to angular measure.

"We will reckon all angles of rotation from the *mean position** as zero, and denote by ϕ the angle of deflection through which the magnet, &c., is turned from this position. As scale-deflection, we take the difference, n, of the observed from the middle scale division.

(1). For small deflections the angle is proportional to the scale-reading; and, indeed, if r be the distance of the reflecting surface from the scale, expressed in scale-divisions (millimetres, if it be a millimetre scale), the value of 1 division in degrees of arc is—

$$= \frac{28{\cdot}648^\circ}{r} = \frac{1718{\cdot}9'}{r} = \frac{103132''}{r}.$$

The error may amount at most in deflections of—

1°	2°	3°	4°	5°
in parts of the whole to—				
0·0004	0·0016	0·0036	0·0064	0·010.

(2). For a deflection not exceeding 6°, we may always with sufficient accuracy take—

$$\phi = \frac{1718{\cdot}9'}{r} n \left(1 - \tfrac{1}{2}\frac{n^2}{r^2}\right)$$

Frequently a trigonometrical function is required instead of the angle itself—

$$\tan\phi = \frac{n}{2r}\left[1 - \left(\frac{n}{2r}\right)^2\right]$$

* An "Introduction to Physical Measurements, with Appendices on Absolute Electrical Measurement, &c." By Dr. F. Kolrausch, Professor-in-ordinary at the Grand Dufcal Polytechnic School at Darmstadt, and formerly Prof. of Physics at Gottingen. Translated from the Second German Edition, by Thomas Hutchinson Waller, B.A., B.Sc.; and Henry Richardson Procter, F.C.S. London: J. and A. Churchill, 1873.

* The *mean position* is the corresponding position of the magnet to the middle scale division.

$$\sin\phi = \frac{n}{2r}\left[1 - \tfrac{1}{8}\left(\frac{n}{2r}\right)^2\right]$$

$$\sin\frac{\phi}{2} = \frac{n}{4r}\left[1 - \frac{11}{2}\left(\frac{n}{4r}\right)^2\right]$$

Hence we reduce a scale reading n to the corresponding arc, tangent, sine, and sine of half angle by subtracting $\frac{1}{6}$, $\frac{1}{3}$, $\frac{3}{8}$, or $\frac{11}{32}\frac{n^3}{r^2}$ respectively from n.

(3). For considerable deflections—

$$\phi = \tfrac{1}{2}\tan^{1-}\frac{n}{r}$$

The last formula is given by simple geometrical considerations, the others by taking the first two terms only of the series for the development of ϕ, $\tan\phi$, &c.

To congratulate the translators, who have added several useful tables and appendices, is needless; the book will be invaluable to every physicist.

MATHEMATICS FOR NON-MATHEMATICIANS.

By W. PAGET HIGGS, LL.D., D.Sc.

Division I.—The Algebra of Constant Quantities.

(Continued from p. 300.)

Division, Fractions, and Ratio (continued).

We may now turn our attention to fractions. Fractions appear to be to many the most difficult section of elementary mathematics; and treated in the abstract there is no doubt there must be attained a high mental culture before their meaning and powers can be fully understood. Indeed, it would seem impossible to impart to one entirely ignorant of mathematics a knowledge of fractions from merely their abstract consideration. In dealing with this section of our papers it will, therefore, be forgiven us if we incline to more concrete detail than the reader may think necessary.

What is a fraction? A fraction, says Mr. Merrifield, in his admirable text-book of arithmetic,*—a fraction of anything is a given portion of it. If we divide anything, no matter how, any piece of it is a fraction of it. The simplest fraction is *one-half*, and is expressed as follows: $\frac{1}{2}$. If we divide a thing, say a cake, into three equal pieces, and take one of them, we call that piece *one-third* of the cake, and we express it as a fraction thus—$\frac{1}{3}$; and so, if we divide it into four, and take one portion, we call it a quarter, or one-fourth, and write it $\frac{1}{4}$. So, also, if we divide a cake into x pieces, we should call each piece $\frac{1}{x}$; if into a pieces each would be $\frac{1}{a}$. It is evident that the whole cake may be considered as two halves (which we write $\frac{2}{2}$), three thirds ($\frac{3}{3}$), four quarters ($\frac{4}{4}$), and the same with any other number. Again, since we cannot divide a cake into less than two pieces, it is clear that division by the number *one* leaves it just as it was, one whole cake, which we may therefore write $\frac{1}{1}$, and this is all we mean by writing—

$$1 = \tfrac{1}{1} = \tfrac{2}{2} = \tfrac{3}{3} = \tfrac{4}{4} = \tfrac{5}{5}\tfrac{6}{6}\tfrac{7}{7}, \text{ \&c.}$$

If we divide the cake into a good many parts (say 12), and take any number of these parts (say 7), we express the whole portion taken thus: $\frac{7}{12}$. The number below the line is called the denominator, and expresses the number of parts into which we divide the thing; the number above the line is called the numerator, and expresses the number of parts taken:—

$$\text{Fraction} = \frac{\text{numerator}}{\text{denominator.}}$$

Premising that our arithmetical knowledge extends thus far, we may take those rules given for the working of fractions, and endeavour to see in what manner they apply. The rules are concisely stated, as—

Rules for Fractions.

Addition and Subtraction.—If the fractions have a common denominator, add or subtract the numerators, and place the sum or difference as a new numerator over the common denominator.

If the fractions have not a common denominator, they must be reduced to that state before the operation is performed.

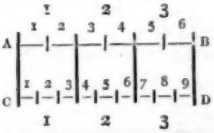
Multiplication and Division.—To multiply a fraction by an integral quantity, multiply the numerator by that quantity, and retain the denominator.

To divide a fraction by an integral quantity, multiply the denominator by that number, and retain the numerator.

To multiply two or more fractions is the same as to take a fraction of a fraction; and is, therefore, effected by taking the product of the numerators for a new numerator, and of the denominators for a new denominator. (The product is evidently smaller than either factor when each is less than unity).

To divide one fraction by another, invert the divisor, and proceed as in multiplication. (The quotient is always greater than the dividend when the divisor is less than unity.)

Now we find in the first words of our first rule the phrase "common denominator." We may, to the better understanding of this phrase, take an arithmetical example. Let us divide two lines into a number of equal parts—the line A B into 6 parts, and the line C D into 9 parts:—



Now the line A B will represent a denominator of 6, and the line C D a denominator of 9. For a numerator (the number of parts we take) let us write down 2. We see that two-sixths, three-ninths, and one-third are the same. So that were we asked to add together three-ninths and one-third, we should reply that the answer was two-thirds. Unconsciously we have performed the operation known as "*reducing the fractions* ($\frac{3}{9}$ and $\frac{1}{3}$) *to a common denominator*"—that is, we have found the value of three-ninths in thirds. While the *denominations* of the quantities were different we could not add them, but directly the value of one in terms of the other was known addition could be proceeded with.

* "Technical Arithmetic and Mensuration." By Charles W. Merrifield, F.R.S., Principal of the Royal School of Naval Architecture and Marine Engineering, &c. Longman's "Text-Books of Science." 1872.

To reduce fractions to a common name or denominator the following rule is generally given:—

Multiply *each* numerator by the *product* of all the denominators *except its own;* the results will be the numerators of the new fractions.

The *product* of *all* the denominators will be the new denominator common to all the new fractions.

To apply our rule, let it be required to add—

$$\frac{a}{b}+\frac{c}{d}+\frac{e}{f}.$$

We have—

$$\frac{adf}{bdf}+\frac{bef}{bdf}+\frac{bde}{bdf}=\frac{adf+bef+bde}{bdf}$$

as the sum. The fractions—

$$\frac{a}{b}+\frac{c}{d}+\frac{e}{f}$$

have not been altered; they have, by the multiplication in each case of numerator and denominator by an equal quantity (see p. 300), taken a new form. The equal quantities are for a over b, df; for c and d, bf; and for e and f, bd. And these equal quantities have been determined by the fact that bdf is a product that contains all these factors—in other words, by the fact that bdf is a common multiple of b and d and f. The reduction of fractions to a common denominator is then resolved into finding a common multiple of the denominators of all the fractions, and multiplying the numerator of each fraction by the factors foreign to itself.

It may be remarked that if a common multiple have a common measure or common divisor, the result of the division of the multiple by the *greatest common divisor* or *measure* is termed the *least common multiple*. These phrases are sometimes expressed by the initial letters G. C. M. (greatest common measure) and L. C. M. (least common multiple). A common multiple of 6 and 4 is 24; but the numbers 6 and 4 have a divisor, 2, common to both, and the *least* common multiple of 6 and 4 is therefore 12.

The following formulæ will serve to illustrate the principles of the preceding sections, and to render the reader familiar with the expression of principles in symbols:—

$$\frac{a}{b}=\frac{ma}{mb} \qquad \frac{a}{b}=\frac{1}{b}\times a.$$

$$\frac{a}{c} \text{ and } \frac{c}{d}=\frac{ad}{bd} \text{ and } \frac{bc}{bd}.$$

$$\frac{a}{b}+\frac{c}{d}=\frac{ad+bc}{bd}.$$

$$\frac{a}{b}-\frac{c}{d}=\frac{ad-bc}{bd}.$$

$$\frac{a}{c}\mp\frac{b}{c}=\frac{a\mp b}{c}.$$

$a \mp b$ should be read, a minus *or* plus b, addition or subtraction being performed as dictated by the application of the formula.

$$\frac{a}{b}\times\frac{c}{d}=\frac{ac}{bd}.$$

$\frac{a}{b}$ divided by $\frac{c}{d}=\frac{a}{b}\times\frac{d}{c}=\frac{ad}{bc}$; or—

$$\frac{\frac{a}{b}}{\frac{c}{d}}=\frac{ad}{bc}.$$

And the following examples given by Prof. De Morgan will prove useful:—

$$\frac{1}{a+\frac{1}{b}}=\frac{b}{ab+1}.$$

$$\frac{1}{a+\cfrac{1}{b+\frac{1}{c}}}=\frac{1}{a+\frac{c}{bc+1}}=\frac{bc+1}{abc+a+c}.$$

Thus—

$$\frac{1}{6+\cfrac{1}{7+\frac{1}{8}}}=\frac{1}{6+\frac{8}{57}}=\frac{57}{350}.$$

PRACTICAL ELECTRO-PLATING.

Coating with Nickel.

Napier, in his "Manual of Electro-Metallurgy," speaks of nickel coating; that it is very easily deposited and may be prepared for this purpose by dissolving it in nitric acid, then adding cyanide of potassium to precipitate the metal, after which the precipitate is washed and dissolved by the addition of more cyanide of potassium. The cyanide of potash has proved unsuitable for nickel plating; he says that he coated articles with nickel in 1847, and up to 1853 they still retained their brilliancy and continued untarnished. Napier gives also the following practical instruction for plating, in the following words:—It is indispensable that the battery should be so arranged that the quantity of electricity generated should correspond with the surface of the articles to be coated, and that the intensity should bear reference to the state of the solution, that is to say, that the quantity should be sufficient to give the required coating of metal in a given time, and the intensity such as to cause the electricity to pass through the solution to the articles. It is also essential that the plates of metal forming the positive pole with the solution should be of corresponding surface to the articles to be coated, and face them on both sides. A rough idea may be given here of a plating vessel which is about 6½ feet in length by 33 inches in breadth and 33 inches in depth, and contains from 200 to 250 gallons of solution; the silver or nickel plates serving as electrodes. Two battery troughs are arranged so as to consist of six batteries of three pair intensity. The zinc plates, immersed in the acid from which electricity is disengaged, and the electrode exposed to the articles receiving the deposit, being in proportion.

The vat should contain the solution with the battery having the zinc pole inverted, connecting with rods upon which the articles are to be suspended with wires, and a copper pole is then connected with the electrode. So soon as the articles which are connected with the negative pole of the battery and the electrode connected with the positive pole are immersed in the solution, the galvanic circuit is completed.

To ascertain the amount of metal deposited, it is well to weigh such articles carefully before and after the operation is completed.

Description of an extensive establishment of nickel plating in actual operation for saddlery, hardware, sadirons, bits and turrets, and where 500 lbs. material are daily plated, finished, and brought to market:—

1. It consists of a large wooden box, which is five feet six inches long, fourteen inches deep, and two feet wide, lined with asphaltum varnish so as to be perfectly tight.

2. The capacity of the box is seventy gallons liquid, consisting of hot water, in which three-quarters of a pound of the double salt of sulphate of nickel and ammonia to each gallon are dissolved.

This vat is connected by wires with (3) a *Smee battery*, consisting of six zinc plates, 9×10 inches, which are previously well amalgamated with mercury, (4) and six carbon plates, likewise 9×10 inches. This box may be lined with lead and must contain ten gallons of water, to which twenty ounces of oil of vitriol are to be added. The carbon plates are now put between each zinc plate, and will keep up the evolution of hydrogen gas as soon as put in connection; it will remain in active operation for two weeks, while the zinc plates need no reamalgamation for four months.

5. Copper or brass wire is stretched across the decomposing or plating vat, for suspending the various articles to be plated, which, according to the power of the battery, takes from six to ten hours, but the average will be eight hours. It is fully understood that the ware must be perfectly clean, free from grease or dust before introducing them into (6) the bath. After being taken out from the plating liquid, the articles are washed off with hot water, and polished on a cloth buff with crocus, rouge, Vienna lime, or other polishing powder and oil.

The expense attending the nickel-plating is quite inconsiderable: spoons and forks may be coated completely with nickel for 25 cents per doz.; turrets or check holders, wheel hubs, large bits, and other saddlery trimmings, for 30 cents per doz.; a sadiron, weighing five pounds can be plated for four cents.

The operation is constantly going on: as soon as one set is sufficiently coated it is removed and replaced by another.

The main condition of nickel-plating lies in these points: 1, to have the solution always kept neutral, it is necessary to test frequently the liquid by means of litmus paper, and if the same indicates a prevalence of acid, to add sufficient caustic ammonia to make the liquor perfectly neutral; also to replace occasionally the consumed salts; 2, to have the materials to be plated always perfectly clean, which, if the goods are of iron, can be done by dipping them in a mixture of muriatic acid and water; the least scratches will prevent a complete coating.

Number 30 brass wire for small articles, and number 16 wire for larger copper articles, are used for suspending the ware.

The chloride of nickel and ammonia is much used for plating, requiring but four ounces of the salt to one gallon of water.

A simple nickel-plating apparatus, likewise in full operation, may also be described, as very satisfactory results are daily realised: 1, a bath or vat containing the usual nickel solution of double salt, three-quarters of a pound to the gallon of hot water; five gallons is applied to the porous cell which contains the amalgamated zinc pole three inches broad, seven inches deep, and seven inches long, but touching within one-half of an inch all around from the cell. The copper wire is connected, to hold suspended the articles, such as faucets, pistols, or other ware to be plated with nickel; the operation goes on at once and deposits the metallic nickel from its solutions in the space of three to four hours.

In a synopsis of Adams's claim of nickel-plating for which he obtained four patents, I find that he bases the one of August 3, 1869, on a solution of the double sulphate of nickel and ammonia, and of a solution of the double chloride of nickel and ammonia; the patent, March 22, 1870, on the solution of the double sulphate of nickel and magnesia; and in that of May 25, 1870, for a solution of the double sulphate of nickel and ammonia; while his last patent of March 11, 1873, he claims a solution of either of the soluble salts of nickel, which must be free from the presence of potash, soda, lime, alumina, and nitric acid, or either of them, and free from acid and alkaline reaction, or from either. It appears, therefore, that they are all tending to prove the character of the solutions he uses for depositing the nickel, which, however, have been very clearly described by George Gore, in 1855, and the application of the double salts are published by Smee. Booth's "Dictionary" for 1852 speaks of a nickel battery consisting of either the nitrate or sulphate of nickel and ammonia being used for plating. The preparation of pure metallic nickel, whether from the ore or by re-casting of such granular nickel as is manufactured in Camden, N.J., or as is imported from the English and German manufactories, is generally considered to be a known metallurgical process. Whether the nickel metal contains some carbon or iron, if used as anode, matters little, for it does not affect at all the operation of plating.

M. Becquerel states that any one may apply the process which Mr. Adams has patented without any infringement; as potash in no way affects injuriously the deposition of nickel, the double sulphate of nickel and potassa as well as the double sulphate of nickel and ammonia can easily be applied; while the special feature of Mr. Adams's patent consists in the exclusion of the smallest quantity of potash, soda, or other alkaline earth from the bath, containing the nickelising preparation, pure double chloride of nickel and ammonium or the perfectly pure sulphate of nickel and ammonia may therefore safely be employed.

Nagel's process for electro-plating with nickel or cobalt is likewise based upon applying the double salts of sulphate of nickel and ammonia or double salts of sulphate of cobalt and ammonia with the platinum positive pole. It consists in taking 400 parts of the sulphate of nickel and 200 parts ammonia, dissolved in 6000 parts of hot water and the ammonia of 0·909 spec. gravity, heated to 100° F.; and if cobalt, but 138 parts of the sulphate of double salt are employed.

Mr. Beardslee, who is unquestionably the veteran in nickel plating in the United States, informs the author that ever since 1858, he has coated metals with electric currents; that he found the chloride of nickel with a certain quantity of ammonia to be of great service,

He attributes any failures in depositing nickel to the following requirements:—

1. Nickel must have a perfectly uniform and unchanging current of electricity; a Smee battery, with a chromium negative plate, gives a powerful and constant current of electricity.

2. The nickel solutions with the chloride solutions may work better with acid instead of alkaline reaction; he quotes, as instances, that he had 2000 gallons of nickel solutions since 1868 and 1869, in constant use without any addition, but have been corrected from time to time in order to give them an acid reaction, as the tendency in working is to become alkaline.

The author begs, however, to close this pamphlet and the subject of nickel plating, by remarking that sulphate of nickel and ammonia will work better if kept under an alkaline reaction.

The following remarks, given to the author by Mr. Beardslee, are of much importance to those who wish to be fully posted:—

He uses two cells of the chromium negative plate battery; the amount of battery power required for a given quantity of work to be done should be in zinc surface, equal to the surface to be quoted.

The surface of the nickel anode should in no case be less than the surface to be coated. The anode surface for a nickel solution may be much greater than the surface to be coated; and more and better work will be the result.

For a nickel solution of 40 gallons, 10 anodes of 6×12 inches are required, and in proportion to the greater or less quantity of gallons. By estimating 7½ gallons to each cubic foot, we can determine the amount of solution that will be required for a vat of any given size.

The nickel anodes are connected with the negative plate of the battery, which may be either the chromium or carbon plates; the articles to be coated are connected with the zinc pole of the battery.

In one gallon of the nickel solution, a nickel anode of 4×6 inches is employed for coating small articles from two one-gallon cells of the chromium negative plate battery.

Stolba's method of nickel-plating by means of chloride of zinc has lately been introduced for coating iron, steel, copper, brass, zinc, or lead. He recommends the chloride or sulphate of nickel as simple salts (which need not be chemically pure).

To a portion of chloride of zinc twice the volume of water is added, the mixture is then boiled, and hydrochloric acid is slowly added, until the precipitate formed by the dilution re-dissolves again. A very little zinc powder is added, and in a few minutes the vessel is coated with zinc wherever the liquid is in contact with it. Nickel salt is then added to it in sufficient quantity to impart a green tint to liquid. The articles to be plated are then introduced, along with a few cuttings of zinc, making as many points of contact as possible; the mixture is to be boiled for about 15 minutes, when the coating is complete.

THE American Government contemplates running a line of telegraph along the coast of New Jersey from Sandy Hook, at the entrance to New York Harbour, to Cape May, at the mouth of the Delaware. This line is to connect the various life-saving stations on the New Jersey coast, and it is to be used to order the display of cautionary signals. A similar survey has been made along the coast of Massachusetts for the same purpose.

LIGHTNING AND LIGHTNING-RODS.*

By JOHN M. MOTT.

(Continued from page 283.)

A KNOWLEDGE of the laws of electrical induction, accumulation and conduction, together with a clear understanding of the action and value of points, will enable us, without difficulty, to arrive at correct conclusions in relation to the application of lightning-rods to buildings. The free electricity with which buildings are charged by induction will, in every instance, accumulate with the greatest intensity upon the ridges and gables, sometimes with greater intensity at one gable than at another. It is therefore absolutely necessary to place a point at each gable, to discharge the accumulated electricity there held by the opposite force contained in the approaching cloud; to place a point at each chimney or ventilator, to offer a line of superior conduction to that offered by ascending smoke, current of heated air, or other gaseous matter; to connect all these points together with rods placed along the ridges, and also to connect them with the gas pipes, water pipes, steam pipes, speaking-tubes, or other metallic substances about the building. The more numerous the connections with the earth the better, not only to provide sufficient lines of conduction, by means of which we may so far neutralise the passing cloud as to prevent a disruptive discharge, but also to give the electrical agency an ample line of conduction, so as to prevent intermediate explosion during its transmission. As we depart from this system of applying rods the protection diminishes. Each ground rod should have several branches penetrating the earth to permanent moisture, and where it is difficult to obtain such a termination, they should be imbedded in charcoal. An improper termination of a lightning-rod is to connect it with the gas or water pipes of a city or village beneath the surface of the earth. Theoretically, it is the best possible termination; practically, one of the very worst.

The experiment of Coulomb demonstrating that free electricity resides almost exclusively upon the surface of an *insulated* conductor has proved to be as much a stumbling-block to many electricians as the one fluid theory of Franklin, and his theory of the action of points upon electrified clouds. Since the molecules in the interior of a conductor discharge with equal readiness on every side, there is no chance for them to become charged; but at the surface of an *insulated* conductor the molecules have conducting molecules upon one side of them, and non-conducting molecules upon the other side; hence their polarisation must be followed by the charged state.

Trees near dwellings do not, as many suppose, afford protection; on the contrary, they increase the danger to persons or property in their vicinity and the necessity of using lightning-rods to prevent damage. They offer facilities for a direct discharge, consequently objects near them are in great danger from the return stroke. The fact that trees are injured by lightning is proof that they are poor conductors, while the large numbers of persons and animals annually killed near them by this same

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* Abstract of a paper read before the Meteorological Section of the Franklin Institute of Philadelphia. From the "Journal of the Franklin Institute."

element is conclusive evidence that they do not afford the protection claimed.

In newly settled countries the cabins are usually provided with stoves, the pipes of which project through the roof; while these pipes do not in the least attract electricity, they furnish a path of less resistance than that of the surrounding air for its passage, the effect of which has often proved fatal to the occupants.

Barns are very frequently destroyed by lightning. This is owing to several causes: first, efficient lightning-rods have not been erected in a proper manner; second, the combustible material they usually contain and the comparative ease with which it is ignited; third, they are sometimes filled with hay or grain imperfectly cured or dried, and are also not unfrequently left during the season of thunder-storms surrounded by decomposing vegetable and animal matter. These substances ferment, or "heat," as the farmers term it, and as the gas or vapour rising from the mow or yard into the atmosphere above the barn furnishes a line of less resistance than the surrounding air, it becomes a part of the line of discharge when the cloud approaches sufficiently near so that the electrical attraction between the opposite electricities can overcome the resistance.

The annoying and disturbing effects of lightning upon the telegraph are caused by conduction and induction, A charged cloud often covers a space of a hundred square miles or more, extending over lines of telegraph, The point of disruptive discharge may be at a distance of many miles from the wires. When the cloud is over the wires they become charged by induction, and when the discharge ensues, from any point, induction instantly ceases and the wires return, like other objects, to their normal condition.

The effect of this return is often observed upon the instruments when the operator is too far from the point of the discharge to see the flash or to hear the report.

Mr. Crosse, of Bloomfield, England, has, by means of wires about one-third of a mile in length, insulated, and supported by means of poles and trees in his park, frequently succeeded in conducting from the atmosphere sufficient electricity to charge and spontaneously discharge a battery of fifty Leyden jars, containing seventy-three feet of coated surface, twenty times in a minute, accompanied by reports as loud as those of a cannon. Telegraph wires conduct free electricity from strata of charged atmosphere in the same manner as the suspended wires of Mr. Crosse, and as the insulators become covered with a thin film of moisture, by the condensation of aqueous vapour, they allow the electricity to pass from the wires to the poles, and as these are imperfect conductors the phenomenon of a disruptive discharge frequently occurs, attended with its well known consequences. If each pole had a wire extending its whole length, attached to it by means of a few small staples, such phenomena would be entirely unknown.*

The free electricity from charged strata of air is frequently conducted by the wires into the office in such quantities as are sufficient to melt the fine wire of the instruments.

It is by making a practical application of our knowledge of the effect of points when attached to charged bodies, namely, increasing the intensity sufficiently to cause a free discharge at any given point, that the instruments and operators are preserved from destruction by lightning.

Oil tanks about the oil distilleries have been exploded; fires have ensued involving great loss, supposed to have originated by the tanks being struck by lightning. These tanks are immense air-tight vessels, with the upper portion in the form of a dome.

The lighter portions of these coal oils rise to the top of the dome. These volatile oils are very inflammable, and when mixed with air are as explosive as gunpowder. The atmosphere about the tanks is filled with gas from these oils. The iron tank being a good conductor, well connected with the earth by means of the pipes running to the distilleries, would be easily charged by induction in case a charged cloud should be near it. Its form is such as to secure the maximum amount of accumulated electricity. The tank itself will not offer the least possible attraction for the electricity of the cloud, while the free electricity with which it is charged, by induction, offers great attraction. If a discharge should occur, the inflammable gas about the tank would be ignited before the electricity would reach the tank, and the most disastrous oil explosion and conflagration would ensue, notwithstanding the fact that the tank has sufficient conducting power to conduct with safety every discharge of electricity which may fall upon it from now to eternity.

This tank, which seems, to persons not conversant with electrical laws, to be most safe from injury by lightning, is known, by those who are familiar with such subjects, and who exercise their reasoning faculties, to be exceedingly defected, and in imminent peril during the passage of electrified clouds. A rod of iron or copper, attached to the dome and terminating in a finely plated point, would be a part of the tank, and would perfect its construction. The tank would not now remain in a charged condition; hence there would be no attraction about it. The point would permit a flow of electricity from the earth towards the cloud, and would tend to prevent an explosion. Oil tanks thus protected would not be injured by lightning.

To escape injury from ligl tning, protect buildings as herein directed, and remain in them during thunder-storms. Keep out of cellars, and avoid being near trees during the passage of electrified clouds. In case the gas or water pipes of a building are not connected with the lightning-rods, it is not safe for a person to remain in a position in which his body would become part of the line of least resistance between them. Beds should be removed from the walls. Persons in chairs should be in the centre of the room, and keep their feet off the floor.

The height a rod extends above a building has no influence whatever upon a discharge of electricity further than arises from the fact of its offering a path of less resistance than the surrounding air before the discharge takes place. It is for this reason, solely, that the rod is carried a short distance above the ridge of a building, and is projected above the tops of chimneys, ventilators, &c. It cannot be supposed for a moment that an agency which moves with such terrible velocity and irresistible force as lightning, could be

* The writer seems to be unaware that this principle is adopted.—Ed.

arrested in its onward course and drawn aside by an insignificant piece of metal in the form of a lightning-rod. If metal does possess this power of arresting lightning, the use of metallic eave-troughs, steam pipes, gas pipes, water pipes, speaking tubes, bell wires, bells, valleys on roofs of buildings, chimney tops, cornices, &c., in and about buildings, should be at once discontinued, as they may attract more electricity than they can carry off. The idea that metal attracts electricity is unsupported by any fact, and is absolutely at variance with the whole course of experience. Such an opinion has arisen entirely from assumption and a partial consideration of facts, or from superstition, prejudice, or unadulterated ignorance. Lightning-rods do not attract lightning. They have no influence whatever upon a thunderbolt after it has started, to restore the equilibrium. The height they project above the building is of but little consequence, providing they be kept *low enough* to withstand the storms. There is no law governing the lateral extent to which a rod affords protection, this being dependent upon the form of the object to which it is applied and the position of the electrified cloud.

Summary.—Insulators, glasses, at the points of support, are of no use in any case; they destroy the most valuable influence of the rod, and may, under certain circumstances, be the cause of most terrific and destructive return strokes.

The conducting power of lightning-rods is proportional to their solid contents, or sectional area, with similar metals of equal lengths, and not to their surfaces.

A lightning-rod should have the conducting power of a copper-rod one-half inch square, and perfect metallic union of all its parts. A rod made exclusively from copper wires, if of sufficient size, constitutes one which is perfect in theory.

Sharp points for the upper termination of rods are necessary. Rods are of but little value without them. Points should be plated, to prevent oxidation. They are also of value when used at the lower terminus of the rod.

It is necessary to place a point at each gable, chimney, and ventilator; to connect all together; to connect the rod with metallic roofs, gutters, valleys, steam pipes, gas pipes, water pipes, speaking tubes and other permanent metallic bodies about buildings, and the more numerous the connections with the earth the better.

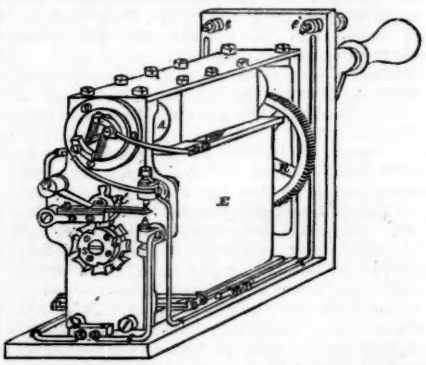
Ground rods must have two or more branches penetrating the earth to permanent moisture; must extend below the foundation walls or the bottom of the cellar. In some instances, where it is difficult to reach moist earth, they must be imbedded in charcoal.

On Thursday, the 9th inst., the workmen of the Penygraig Colliery, Rhondda Valley, presented a testimonial to R. Rowlands, Esq., manager of the colliery. The testimonial consisted of an illuminated address engrossed on vellum by Mr. Daniels, of Liverpool—a handsome watch and chain each for Mr. and Mrs. Rowlands—and a purse containing about £150. The watches were Keyless English ¾-plate Levers, with chronometer adjustments for temperatures, and specially manufactured by Mr. Streeter, of London, the one presented to Mr. Rowlands bearing the following inscription:—"Cyflwynedig i Mr. Rowland Rowlands gan weithwyr Glofa Penygraig a chyfeillion ereill.—*Observer, October 19th*, 1873.

SIEMENS'S DYNAMO-ELECTRIC APPARATUS.*

In the earlier Siemens's Magneto-Electric Machines the inductive action of permanent steel magnets on a revolving Siemens's armature was employed for generating the currents. In the machine to be described electro-magnets are employed instead of permanent steel magnets; the residuary magnetism left in the coils of the electro-magnets, after a current from even a single voltaic cell has been once sent through them, is found sufficient to always have the necessary inductive action on the armature. This inductive action, although very weak at first, generates slight alternating currents in the armature, which are, by means of a commutator, caused to flow always in one direction through the coils of the electro-magnet, thereby increasing the magnetism in the core, which, in its turn, increases the inductive action, causing stronger and stronger currents to be generated in the armature. The magnetism in the core and the induced currents in the armature act and react on one another till the limit of the magnetic capacity of the core is reached. If the coil of the armature is then suddenly connected with a telegraph line, instead of with the coils of the electro-magnet, a short but very powerful current will be sent through the line. If this line is interrupted somewhere for a very short distance, or if its resistance is greatly increased at some point, as by putting a short piece of some badly-conducting material between the ends of the

Fig. 1.



good conductor, a spark is caused to pass between the ends of the good conductor, or the piece of bad conductor is greatly heated, causing its ignition if it is susceptible of being easily fired, as is the case with the composition employed for the purpose in Abel's fuses.

This instrument is besides suitable for releasing clock-work at considerable distances. When used for this purpose, one terminal is to be connected to the line wire, and the other to earth, and the handle of the machine turned when it is desired to send a current.

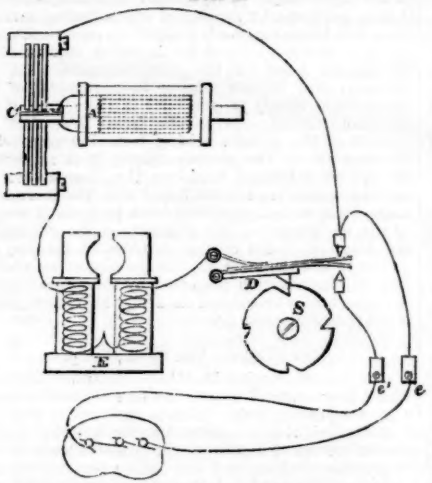
The general appearance of the Dynamo-Electric Machine, with its cover off, is shown in fig. 1, where A is the revolving armature, on the axle of which is a pinion, driven by the wheel B, which is turned by

* Communicated by the Authors.

the handle at the end of the machine, E is the electro-magnet, and C the commutator. The lever D, when in the position shown, establishes short circuit between the coil of the armature and the coils of the electro-magnet; but, after each two revolutions of the wheel R', which is fastened on the same axle as the wheel R, the tooth under the lever falls into one of the notches in the cam S, and thereby causes the upper spring at the end of the lever D to leave the upper contact screw, thus breaking the short circuit, and causes the lower spring to come into contact with the lower contact screw, thus obliging the current to pass into the line, the ends of which are connected to the parts of the terminals *e* and *e'*, which are on the outside of the end of the machine, instead of into the coils of the electro-magnet.

Fig. 2 gives a diagram of the connections of the

FIG. 2.



instrument, the same letters of reference being employed to point out the different parts as in fig. 1.

When the Dynamo-Electric Machine is used as a mine-exploder, the leading wires to connect the machine with the mine to be exploded are inserted in the screws *e* and *e'*; but, to prevent accidents, this connection is not made until immediately before the fuse is to be fired. In order to obtain the whole power of the machine, the handle should be turned round three or four times *backwards* before firing the charge.

It is necessary that one at least of the leading wires should be perfectly insulated from the other, and from contact with the earth; but, in the case of the machine having to be used at a great distance from the mine to be fired, the earth may be used in place of one of the leading wires: if this is done care must be taken to make good earth-connections as for ordinary telegraph work.

It is better to use three or four Abel's fuses in each mine to be exploded, as, if only one is used, a misfire may occur, owing to the fuse having been spoilt.

If one mine only is to be exploded, the fuses should be connected up, so that the current will pass through one fuse after the other; but if more than one mine is to be exploded, three or four fuses should be placed in each mine, and the groups of fuses should be connected to the main leading wires.

Correspondence.

INSULATION.—OUR INDIAN TELEGRAPHS.

To the Editor of the Telegraphic Journal.

SIR,—In the extract given in your number of May 15th, from the *Telegrapher* of April 5th, 1873, headed, "*On Economical Line Construction*," Mr. Brooks, in the second column, enters into a consideration of the gain in money and loss in current produced by using for a land line a thin wire instead of a thick one. He states that when the absolute conduction resistance is increased 22 per cent. the loss so produced can be compensated for by increasing the battery power 22 per cent.

Now this is far from being the case in a long or badly-insulated line, since an increase on the conduction resistance not only diminishes the current leaving the sending station, but in addition diminishes the proportion of the sent current arriving at the receiving station, so that an increase in the conduction resistance produces a double diminution in the received or effective current. This will perhaps be more clearly seen from the following consideration.

Let the absolute conduction resistance of a line be (2 R), the absolute insulation resistance (B), the resistance of the relay at the distant end of the line (D), and the electro-motive force of the sending battery (E), then, if the line be uniformly insulated, and if we neglect the resistance of the battery itself—which is usually small compared with the other resistances in circuit—we have the received current equal to—

$$\frac{BE}{A(2B+D)+A^2+BD}$$

Now if (A) be not small in comparison with (B), which will be the case in a long or badly-insulated line, increasing (A) by 22 per cent will diminish the above fraction by *far more* than 22 per cent; consequently it will require that (E) should be increased by *far more* than 22 per cent to keep the received current constant. The use, therefore, of thick wire for long land lines possesses far greater advantages than Mr. Brooks has attributed to it.

This gentleman then proceeds to quote an article from "one of the London leading scientific journals," in which it is stated that "there is no place in the world where there is such a lack of scientific knowledge in connection with the telegraph service except America as in the British East Indies." Probably this gentleman is not aware that Mr. Latimer Clark (who, when on a visit to India, examined the telegraphs of that country), stated recently, while occupying the President's chair at the Society of Telegraph Engineers, that "although some six years ago the Indian Government Telegraph was, perhaps, one of the most unscientific in the world, that now it had attained the foremost place amongst telegraphic administrations in the application of scientific laws to practical questions."

Mr. Brooks seems also unacquainted with the "Instructions for Testing Overland Telegraph Lines," compiled by Mr. Schwendler, of the Indian Government Telegraph, and issued to the officers of that department June 18, 1869, since Mr. Brooks's "*Method of Determining the Actual Resistance of Old Telegraph Line Wires*," which he gives as new, in the *Telegrapher*, April 5, 1873, may be found not only *in extenso* in the "Instructions" referred to above, but, in addition,

with what is most essential in practice (but what is not given by Mr. Brooks) methods for determining the exact position of the "single leak," and for freeing all the results from the effects of natural line currents.

If Mr. Brooks wishes to see what scientific work is being done, and has been done, by the Indian Government Telegraph, I would refer him to "The Instructions for Testing Telegraph Lines, and the Technical Arrangements in Offices," the first part of which was published in the beginning of 1872 by that department, the second and third parts being probably also now ready. These "Instructions," in three parts, are founded on those issued in 1869, but are much more elaborate and complete.—I am, &c.,

W. E. AYRTON.
Prof. Nat. Phil., The Imperial College of Engineering, Tokei, and Hon. Sec. for Japan of the Society of Telegraph Engineers.

Notes and Queries.

BOILER CRUSTS.

"Steam" asks what is the best kind of battery to attach to a steam boiler to prevent lime deposits? [A constant battery, such as Leclanché's or Daniell's, but we think so much battery power would be required that the application would not pay.]

ELECTRICAL UNITS.

"Honours Science Student" finds himself very much confused in trying to understand the B A units. He asks for information on the subject in the TELEGRAPHIC JOURNAL, for the benefit of students like himself. The value of the various units he finds is so differently stated by various authorities as to make their comprehension almost impossible. For instance, Jenkin, page 162, says: "About one farad per second would flow if one Daniell's cell were employed to produce a current in a circuit, the total resistance of which is one ohm." From this he infers that an E. M. F. of one volt will send a current of one farad per second through a total resistance of one ohm. But Latimer Clark, in his work on Electrical Measurement, makes the farad to be something quite different. On page 44 he says: "The farad is that quantity of electricity which, with an E. M. F. of one volt would flow through a resistance of one megohm per second." Hence Jenkin's farad is a million times greater than Clarke's farad.

SOCIETE INDUSTRIELLE DE MULHOUSE.—PRIZE LIST.—Amongst the prizes offered for distribution, in May, 1874, are the following, which may be considered as relating or effected by electricity. Medal of honour for introducing or manufacturing in Alsace cylinders of cast-iron, covered with copper by electro-plating, which are to be used in printing calicos. First-class medal for a new indicator, specially designed for the spindles of looms, and capable of registering up to 10,000 revolutions a minute. First-class medal for an apparatus transmitting thermometrical indications to a distance.

A RACE TO THE TELEGRAPH STATION.—The United States' Associated Press courier who carried the report of the Modoc execution from Fort Klamath to the telegraph station at Jacksonville, Oregon, rode 92 miles in 6 hours and 55 minutes, over a mountain road of more than usual roughness, employing only three well-selected horses for the journey. The last 42 miles, it is stated, he accomplished in exactly two hours, defeating his principal competitor by 30 minutes, and getting control of the wire, which was necessarily occupied in transmission of the Associated Press report until it was too late to forward any other.

Electrical Science in Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxvii., No. 13.

Note upon Magnetism (Continued).—By J. M. Gaugain.—In the case of a permanent magnet, the curve that represents the currents arising from removal of the armature fall very rapidly from the extremity of the branches to the middle of magnet, and here sensibly coincides with the axis of abscissæ. In the case of an electro-magnet the curve of the currents arising from the removal of the armature differs little from a right line throughout the interval which separates the two bobbins; but this line parallel to the axis of the abscissæ is situated at a great height above the axis. In electro-magnets the increase of magnetisation that results from application of the armature is nearly uniform through the entire length of the horse-shoe. The current of demagnetisation that is produced by rupture of the inducing current, while the electro-magnet is without its armature, varies nearly as the intensity of the inducing current for a determined point of the electro-magnet. On the contrary, the current arising from removal of the armature is clearly proportional to the square of the inducing current. It results from this, that the relation of the current arising from the removal of the armature to the current arising from rupture of the inducing current varies as the intensity of the inducing current. I have found that the increase of magnetisation that is produced in a permanent magnet by the application of the armature is independent of the duration of the contact established between the armature and the magnet. In the case of an electro-magnet, the reaction produced by the application of the armature is completed in a very short time, but it is not instantaneous.

Les Mondes. Vol. xxxii., No. 5.

A New Battery.—By M. l'Abbé Moigno.—The Abbé Filhol has obtained possession of a Spanish mineral, a pyrites perhaps, with which it occurred to him that a battery might be constructed on the following plan:—At the bottom of a glass jar, he places a piece of zinc 20 centimetres long by 8 deep, and 4 across, forming a cup; in this cup he puts the mineral in question, and beneath it a copper plate; he fills the interstices with powdered coke, mixed with one-tenth part of chloride of sodium, or marine salt, and moistens with water. With four elements connected by insulated copper wires, copper to copper, zinc to zinc, he obtained a current of surprising energy, which gave large sparks at the contact of the poles, made an iron wire red-hot, violently rang an electric bell, gave shocks, &c. The Abbé Filhol does not hesitate to affirm that four new couples of equal dimensions display the energy of five couples of Bunsen, that his battery is well adapted to produce the electric light, and, what is more extraordinary, what seems incredible is, that after eighteen months' use of his battery, which he names Constant *Electrogene*, acted as well as on the first day, with the sole condition of keeping it very damp. M. Delaporte, electrical engineer, will shortly make a trial of this marvellous electrogene, and I will render a faithful account of it.

New Industrial Generator of Electricity.—A description of Messrs. Mure and Clamond's thermo-pile, described in this journal, page 11, vol. I.

Journal of the Telegraph. Vol. vi. Whole No. 142.

Management of Batteries.—By C. H. Haskins, Western Union Co.—The Hill battery, an American invention, has been in use for several years, with varying success. Since the introduction of the

Callaud, the same variety of opinion prevails with regard to its utility. Why this diversity of opinion? Simply, because the philosophy of action of the battery is not understood. A thorough knowledge of its peculiarities will enable any one to work and manage a gravity battery with entire success. And the foundation of it all, is this law: *The amount of current flowing to line is in inverse proportion to the resistance in the circuit.* And: The consumption of material is determined by the amount of current furnished to the line. Or, in other words, the chemical action of the battery is in direct proportion to the work performed. Hence it follows, that the amount of sulphate of copper converted or consumed in one battery, gives you no result from which to calculate the consumption in a battery on a line of different resistance. And this brings us to the foundation of all the trouble experienced. The jars have been charged with an arbitrary amount of sulphate of copper, regardless of the resistance of the circuit. The blue vitriol is dissolved by the water, and unless the action of the battery is sufficient to convert the vitriol as rapidly as it is dissolved, the blue solution will rise until it comes in contact with the zinc. In local batteries this is seldom the case; for the total resistance in circuit is but a few units, and the blue vitriol is converted as rapidly as it is dissolved. But batteries on main circuits are so choked back by the line resistance—unless the line is very short—that the vitriol is dissolved with greater rapidity than it is used. Consequently, the copper soon deposits upon the zinc discs, and the battery is ruined. My rules are: to drop a piece of vitriol of the size of a walnut, into each jar, when it is set up. Let this dissolve, then add small crystals, until the blue solution is, say two inches high, from the bottom of the jar. Instruct your battery man to add the crystals daily, keeping the solution as near as possible at the above height. Wipe off the outside of the jar, and the inside, above the fluid, daily, to remove the salt of zinc that may be deposited there by evaporation. When the sulphate of zinc solution becomes syrupy, like strained honey, or begins to deposit crystals on the zinc disc, draw off half of it with a syphon, made of twelve to eighteen inches of soft rubber tubing, and fill with fresh water. See that fresh water is added, to replace that lost by evaporation. Keep the battery room warm and dry. These rules do not require severe study, or a knowledge of chemistry. They are easily understood, and efficacious. I have yet to find any one so ignorant or stupid as to fail in applying them successfully. One battery, working two wires, was set up March 17th, 1872; another with four lines, July 1st, same year. These are both Callaud. A Hill, put up in July last year, is still working beautifully. Several others have been working from six months to one year each. None of them have been taken down, and all are clean, and working well. It is a mistake to suppose that the action of a sulphate of copper battery is increased by "crowding it" with an excess of sulphate of copper. So long as there is even a small portion of blue vitriol solution in the jar, its action is as vigorous as if there were a gallon. And I repeat, whenever there is an excess, and the consumption per minute is less rapid than the solution of the crystals by the water, this solution must rise until it reaches the zinc. The sulphate of copper is sparingly soluble in water, and when you lessen the external resistance, by adding lines, you soon reach the limit of its capacity to supply the blue solution as rapidly as it is needed. The average of lines to be worked economically from the sulphate of copper battery is four or five. I prefer the lesser number. As the internal resistance of a main battery is exceedingly small, compared with that of the line, it may be practically disregarded. I therefore use but one-fourth of a pound of sulphate of zinc to each jar, when setting up a new battery. Callaud's plan o lowering the zinc, to decrease the internal resistance in a main battery, is entirely useless, and from the loosening of the binding screws and consequent dropping of the zincs, this arrangement of hanging the discs is actually a detriment to the battery instead of an advantage. The only safe way is to hang the zinc the proper height, and then bend over the top of the suspending wire and cut it off, leaving it in the form of a hook on top of the binding screw. I have remedied this trouble in the zincs used by this company by casting a copper wire loop in the top of the stem, through which passes a round wooden rod, across the top of the jar. Thus the zincs are all at an equal distance from the bottom of the jar, and the internal resistance of all the jars must be alike. I use the same style and size of zincs, coppers, and jars, for main and local batteries.

Journal de Physique. September, 1873.

On a Modification of the Electric Thermometer.—M. Mascart.—This instrument consists of a helix of platinum wire joining two metallic armatures, and enclosed in a glass tube, the whole being supported vertically. Each of the armatures has a hook with ball, for the study of discharges of static electricity, and a binding-screw, for the study of currents. The upper armature has, besides, a tubulure, by which one may with a caoutchouc pipe put the air of the thermometer into communication with a manometer, so as to observe the changes of pressure produced by heating the wire. It is, in short, a Riess thermometer in which the mass of air is reduced as much as possible so as to obtain great sensibility. The apparatus may be made to record its indications, and for this purpose it communicates with a membrane and lever like those used by M. Marey in his physiological experiments. The membrane is of caoutchouc, stretched across a metallic capsule, and on it is a metallic plate, which acts, by a short point, on a very light lever. The small displacements which variations of pressure impress on the membrane are communicated to the lever, which magnifies them and inscribes them on the smoked paper on a rotating cylinder. The author reproduces the curves obtained from discharges of electric batteries and from continuous currents. There is (in the former) first a straight line, the tracing before discharge, then a curved rise and very gradual descent, showing the successive variations of pressure due to heating of the wire. It is noted that the heating of the air is not instantaneous; it quickly reaches its maximum, and then diminishes in a regular manner. The examination of the second part of the curve gives an opportunity to study the law of cooling. Further, with a constant charge the quantity of heat furnished by the spark diminishes when the number of jars is increased; and with the same battery, the heat of the spark increases rapidly with the charge. It is shown by numerical verification that the quantity of heat liberated is about inversely as the number of jars in the battery, and that it is nearly proportional to the square of the charge. A figure is given, showing the curves obtained by sending through the wire of the thermometer the current furnished by a Gramme machine worked at different velocities. Turning the machine with the hand, and observing a metronome, one is able to maintain a pretty uniform rate. The curves show that the heating of the wire is progressive, and that it takes a considerable time to reach its maximum. The quantity of heat liberated is, according to Joule's law, proportional to the resistance of the wire and to the square of the intensity of the current; if the intensity of the current is proportional to the velocity of rotation, the quantity of heat will be proportional to the square of the number of turns. This is confirmed by tabulated results.

City and Commercial Notes.

TELEGRAPH Construction shares were pressed for sale on Tuesday, the 28th ult., on a rumour of a strike at the works. There was no foundation whatever for this report.

The Eastern Telegraph Company, Limited, have issued the following memorandum:—"On and after the 15th November next, *ten word messages for India* at the reduced rate of £2 will be accepted by the Eastern Telegraph Company at their station, 74, Old Broad Street, London, and at all the Postal Telegraph Stations throughout the Kingdom, when ordered *via* Falmouth. Four shillings will be charged for every word in excess of ten words. Negotiations have been for some time in progress with the Indian and other Governments for the introduction of a one-word tariff to India, Australia, and China, similar to that in force on the Anglo-American lines, but owing to the necessity of obtaining the general consent of all the contracting powers to the Convention of Rome, it is feared that the alteration cannot be brought into operation before the next International Telegraphic Conference, which will be held in 1875.—66, Old Broad Street, Oct. 22, 1873."

The Eastern Telegraph Company, Limited, have notified that their direct cable between England and Lisbon, as well as the cable between Vigo and Lisbon, is interrupted. Messages for the Peninsula are sent as usual *via* Vigo, while the traffic for Malta, Egypt, and the East is directed *via* Marseilles. The company's repairing ship, the *Hawk*, is engaged in repairing the direct cable, and will proceed in a few days to restore the communication between Lisbon and Vigo. The break in the direct cable is understood to be near the shore.

Reuter's Telegram Company and the Indo-European Telegraph Company, Limited, notify that the cable between Singapore and Hong Kong having been repaired, messages to China and Japan may now be again sent direct *via* Teheran."

A general system of telegraphic communication throughout Brazil is being rapidly and successfully completed. On the 14th of June last, the *Hooper* steamship left the Millwall Docks with the length of cable to be laid between Pernambuco and Para. She arrived at Pernambuco on the 30th July, and was joined by the *Great Northern* at Para on the 30th of September with shore ends. After having completed the section she returned to England, arriving at Millwall on the 4th instant, having made a very successful voyage. The *Great Northern* remained at Para for 30 days, when, the tests showing the cable to be in excellent condition, she returned with the electrical staff of the Hooper Company, arriving at Millwall on Monday, the 27th ult. The *Hooper* is now loading the second section—1500 miles in length—of the Brazilian cable in the Millwall docks, and she is to start on her important mission next Tuesday. Her work is to lay a cable from Pernambuco—where it will be joined up with the section just laid—to Bahia, and from Bahia to Rio de Janeiro. At the latter point the *Hooper* cable will be coupled up with the Plato-Brazilian Company's line, which company will lay a cable from Rio to Maldonado. From the latter point the Montevidean Company will lay a cable to Montevideo, which will be united to the Buenos Ayres cable which already exists in connexion with the Trans-Andine land line company connecting with Valparaiso. The Brazilian Submarine Company are laying a line from Lisbon to Madeira, and from the latter place to St. Vincent, and thence to Pernambuco. Thus, in a short time, the entire coast of Brazil and of the Argentine Confederation will be brought into direct telegraphic communication with England. In order to commemorate the successful laying of the first section of cable, and to wish good speed to the second, there was a general gathering of officers and gentlemen interested in the question of electric telegraphy on board the *Hooper* yesterday. Besides the gentlemen officially connected with the Hooper Company, who are manufacturing and laying the cables, and of the Western and Brazilian Telegraph Company, for whom they are being made and laid, there were present General Tremenhere, Colonel Milward, Colonel Campbell, Colonel Stotherd, Colonel Galwey, Captain Luard, Lieutenant Watson, Professor Abel, Sir F. Chapman, Mr. Danvers, of the India Office, Mr. Erichsen, representing the Great Northern Telegraph Company, and others. A general inspection of the ship by the visitors, and an examination of the various sections of *Hooper* cable already laid, was followed by a luncheon on board.

TELEGRAPH SHARE LIST.

Amount per Share.	Name of Company.	Amount paid up.	Closing Quotations.
£		£	Oct. 30.
Stock	Anglo-American (Limited)	100	86½—87½
10	Brazilian Submarine..	9	2½—2 dis.
10	Cuba	All	8¾—9
10	Direct Spanish	9	1 dis.—par
20	Direct United States Cable	11	7—5 dis.
10	Eastern (Limited)	All	8¼—8⅝
10	Ditto New	All	—
10	Eastern Extn. Australia and China	All	8⅜—8⅝
10	Great Northern	All	8⅜—9¼
25	Indo-European	All	15—17
10	Mediterranean Extension (Limited)	All	4⅜—5¼
10	Do., 8 per cent Pref...	All	11—12
10	Panama and South Pacific	2½	3¼—2½ dis.
8	Reuter's..	All	10—11
Stock	Submarine	100	245—255
1	Do., Scrip	All	2¼—2½
10	West India and Panama	All	5¼—5⅜
10	Do., 10 per cent Pref.	All	10—10½
20	Western and Brazilian (Limited) ..	All	12—14
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	92—94
10	Hooper's Telegraph Works	All	11¼—11⅝
50	India-Rubber and Gutta Percha ..	All	29—31
Cert.	Submarine Cables Trust	100	108—110
12	Telegraph Construction	All	30¼—30⅞
100	Ditto Ditto 7 per cent Bonds	All	102—104

THE TELEGRAPHIC JOURNAL ALMANACK.

We have to draw the attention of officers and others of the telegraphic community to the approaching publication of a professional almanack. We ask our readers to send *any* information that may appear to them to be useful for the purpose, so as to render the almanack as inclusive as possible.

CORRECTION. — In Mr. Sabine's contribution on "*Earth Electricity*," in our last number, an omission had been made in copying the MS. which was not discovered in time for correction. At page 301, line 38 from top, instead of "a charged Leyden jar upon its surface," read "a charged Leyden jar, *when connected with the two poles of any source of electricity, but otherwise insulated from contact with objects*, upon its surface," &c.

To Correspondents.

Our "Students' Column" and the "Papers for Junior Students" are unavoidably crowded out of this number by press of other matter.

PROF. AYRTON (Japan).—The authorities for the statement to which you give a counter-quotation were Weber's "Researches" and Clark and Sabine's "Electrical Tables and Formulæ." The statement as to capacity supposes no absorption. We will call attention to the remarks.

F. E. S.—Apply to the makers of the cable. They will probably have a piece of faulty core by them.

HONOURS SCIENCE STUDENT (No. 2).—The sentence is ambiguous: Evidently the meaning is that the values given result from actual experiment, not taking into account the different phases of internal resistance, &c., in the two cases. We do not follow your equation, nor the value obtained. Probably there is a slip of the pen, as the multiplication is at fault. Write again.